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action, in connection with the so-called "avalanche unit" and photons with energies comparable to those of the high-energy electrons. These photons create more high-energy electron pairs which in turn create photons of almost the same energy, etc. After many repetitions of these processes we obtain a great many photons and charged particles of both signs instead of the primary electrons, with the energy gradually becoming dispersed. Obviously, a statistical problem is involved.

Therefore, the number of particles with energies greater than a certain given energy initially increases up to a certain maximum and then quickly falls to zero.

The avalanche unit is determined thus:

$$1/t_0 = 4\pi\epsilon_0^2 \sum n_i Z_i (Z_i + 1) L_i^{rad}$$

where $a = e^2/\hbar c = 1/137$; $r_0 = e^2/mc^2$ (electron "radius"); n_i is the number of atoms of each element in the substance per cubic meter; Z_i is the atomic number; L_i^{rad} is the "radiational" logarithm as calculated by the Pomeranchuk-Kirpicheskiy method (Doklady Akademii Nauk SSSR, Vol XLV, No 7, 1944, p 301).

As the shower progresses and the energy of the secondary particles decreases, the ionization losses and Compton effect become important. This is connected with the critical energy beta:

$$\beta = 110 \sum n_i Z_i L_i^{ion} / \sum n_i Z_i (Z_i + 1) L_i^{rad} \text{ (mev)}.$$

L_i^{ion} is the "ionizational" logarithm, which depends on the energy of the electrons; it must be averaged over the energy spectrum.

The asymptotic expressions for pair production and radiational losses, as ordinarily employed for great energies, becomes quite erroneous for low energies. It can be shown that the greater part of avalanche electrons possess energies considerably less than critical.

Asymptotic cross sections for radiational losses and pair productions are correct for energies satisfying the condition.

$$E > E_{eff} = 68/Z^{1/3}$$

For light elements, e. g., air, the condition is more rigid: $E > \beta$, since for air $\beta = 72 \text{ mev}$. But for lead, we have $\beta = 6.4$ and $E_{eff} = 15.7 \text{ mev}$.

In conclusion, consider the equations of the cascade theory, taking into consideration the ionization losses and the above comments on critical energies and condition. Let $P(t, E)dE$ be the average number of electrons of both signs in the energy interval $E, E+dE$ and let $\Gamma(t, E)dE$ be the average number of photons in the same interval at a distance t from the surface of the layer. The depth t is measured in avalanche units.

The integrodifferential equations determining these functions are to be set up first, with the usual probabilities $W_p(E, E')$ and $W_e(E, E')$ in the kernel. Then the Laplace-Mellin transformation relative to E is applied to them. Next, the "equilibrium" energy spectrum of electrons and photons is determined by integrating $P(t, E)$ over t from zero to infinity. By integration with respect to E , the number of charged particles with energies greater than E is obtained: $N(E)$, the integral spectrum. The spectrum is also found for various depths t .

It is to be noted that Snyder (Phy Rev, 76, 11, 1949) obtained some of the same results, but by a very complicated and cumbersome method.

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